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Characterization of fine particles using optomagnetic measurement

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The rotational dynamic of magnetic nanoparticle (MNP) suspensions in magnetic fields are important for a number of biomedical application ranging from hyperthermia, magnetic resonance imaging (MRI), to bio-detection assays. Recently, optomagnetic measurements have been used to study the change of MNP dynamics in biomedical agglomeration assays [1]. The technique relies on synchronized measurements of the complex 2nd harmonic modulation of light transmission through a suspension of MNPs, $V_2 = V_2' + iV_2''$ in response to an oscillating applied magnetic field, $B(t) = B_0 \sin(2\pi ft)$.

Here, we present measurements of V_2/V_0 , where V_0 is the average transmitted light intensity, vs. the frequency f and amplitude B_0 of the magnetic field on a suspension of MNPs with a remnant magnetic moment and a nominal diameter of 80 nm (#10-00-801, Micromod, DE). Figs. 1a-b show V_2' and V_2'' vs. f for the indicated values of B_0 . We first show that the Brownian relaxation frequency of the MNPs can be extracted as the frequency where V_2'' crosses zero. Next, we demonstrate for the first time that the distribution of MNP remnant magnetic moments can be extracted from the field-dependence of the low-frequency signal magnitude $|V_2|$ (Fig. 1c). The line in Fig. 1c is a fit to a model assuming equilibrium dynamics and the distribution of magnetic moments shown in the inset. The value of the Brownian relaxation frequency corresponds well to that obtained from AC susceptibility measurements and the remnant magnetic moment corresponds well to that estimated from magnetic hysteresis measurements.

The method provides a simple method to characterize MNPs with a narrow size distribution and a remnant magnetic moment in a matter of a few minutes and is thus an interesting alternative to AC susceptibility measurements.

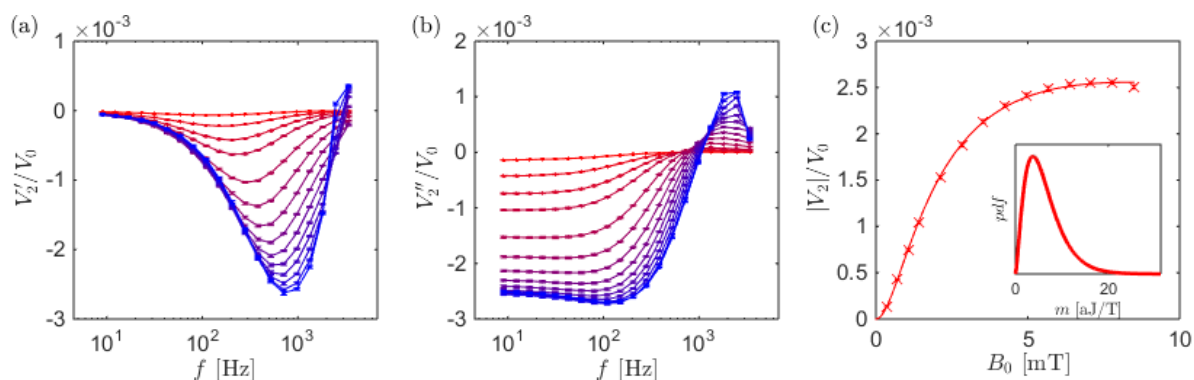


Fig 1. Optomagnetic measurements on a suspension of 80 nm MNPs performed at the indicated values of f and B_0 . Panels (a) and (b) show the in-phase and out-of-phase signals V_2' and V_2'' , respectively, for B_0 ranging from 0.35 mT (red) to 8.49 mT (blue). Panel (c) shows the low-frequency signal magnitude $|V_2|$ vs. B_0 . The line is a fit to a model that assumes equilibrium behavior with the magnetic moment distribution given in the inset.

[1] M. Donolato *et al.*, *Anal. Chem.* **87**, 1622–1629 (2015).

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